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# Microfabrication of grating for X-ray phase contrast imaging

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X-ray absorption imaging is a technique extensively used in medical diagnosis since William Röntgen first discovered it in the late 19th century. This method is today used in medical science as well as in industry or research. However, in many circumstances, there is a need to distinguish between different media, which do not have a large absorption contrast, such as cancerous cells and healthy tissue. X-ray phase contrast imaging (XRPCI), demonstrated in the early 2000s by Momose et al. [1], is a powerful technique that enhances contrast of similar media, with only low absorption contrast. This technique has gained interest due to its ability to work with simple laboratory X-ray sources as opposed to highly coherent beam synchrotron facilities.

In our research, we focus on the fabrication methods of X-ray gratings for phase contrast imaging systems. In the quest to reduce the fabrication cost of these X-ray systems, and especially the optics, we are investigating the possibility to use tungsten as base material for the grating. When compared to gold, which is commonly used in X-ray optic, tungsten has similar X-ray absorption while it is significantly cheaper; thus, tungsten is an ideal candidate material to lower cost of the optical elements. We use laser ablation in air to pattern tungsten sheets. This technique allows to pattern holes and lines down to few micrometers in dimension. Using this technique, we have previously succeeded to pattern 1D gratings with 27 ± 1µm line width in a 50 µm thick W substrate. However, line pattern gratings requires a 90 degree rotation in order to obtain a full 2D image of a sample as shown in Figure 1, thus increasing the time and complexity of the acquisition. In order to overcome these concerns we have fabricated 2D gratings consisting of an array of 17 µm diameter holes as shown in Figure 2. Preliminary results (Figure 3) show that a combination of thicker substrate and smaller holes is needed in order to enhance the signal to background ratio and improve the resolution. We are currently working on the fabrication of a tungsten grid with smaller holes on 200 µm thick tungsten substrates using laser ablation.

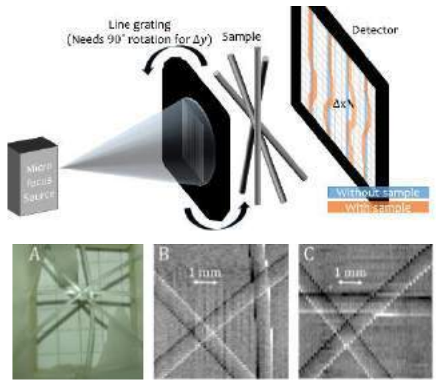


*Figure 1. Top: Single grating phase contrast setup under development at DTU Physics. Bottom: (A) Fishing line used as sample in the DTU Physics setup. (B) Horizontal and (C) vertical X-ray phase contrast images obtained using a 1D grating with 27 µm line width tungsten at a source voltage of 75 kV.*

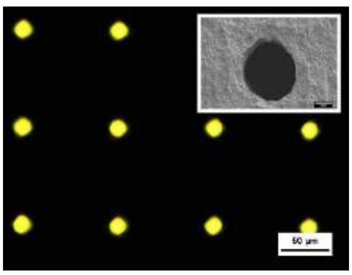


*Figure 2. Microscope dark field image of a 2x2cm 2D holes grating made in 50 µm thick tungsten substrate using laser ablation. Insert: SEM image of 17 ± 0.5µm Ø holes. Scale 5µm.*

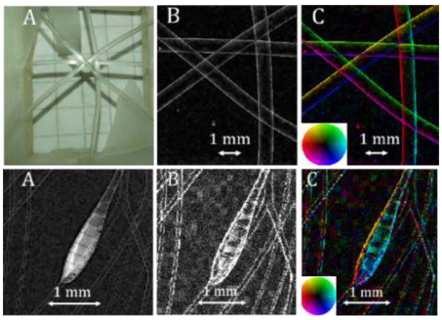


*Figure 3. Result obtained with a 2D grating on 50 µm thick tungsten.
TOP: (A) Fishing line photograph; (B) Phase contrast image - absolute beam deviation, (C) Directional deviation.
BOTTOM: Antenna of a moth on top of wing exoskeleton (A) Standard attenuation (absorption) image; B Phase contrast image, and (C) Directional deviation*

[1] A. Momose et al., Jpn. J. Appl. Phys. **42**, 866-868, 2003.